



# **Opportunities and Complexity In Reducing Mobile AC GHG Emissions**

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Society of Automotive Engineers

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Mobile Air Conditioning Society

# Imagine Affordable Climate Protection

*A global team of industry, government, and public authorities working together to investigate and commercialize new mobile AC technology that helps protect the climate while rewarding vehicle manufacturers, suppliers, service organizations, and owners.*

**CARB!**

## Thank you for putting the environment in the driver's seat!

AC Delco  
ACC Climate Control  
AGRAMKOW  
Airsept  
Alliance of Automobile Manufacturers  
Arkema  
Association of International  
Automobile Manufacturers  
Audi  
Australian Department of Environment  
and Heritage  
Australian Federated Chamber of  
Automotive Industries  
Australian Federation of Automotive  
Parts Manufacturers  
Australian Fluorocarbon Council  
Australian Greenhouse Office  
Automotive Aftermarket Industry  
Association  
Behr  
Bergstrom  
BMW  
California Air Resources Board  
CalsonickKansei  
Centro Ricerche Fiat  
Cicra Automotive  
DaimlerChrysler  
Delphi Corporation  
DENSO  
DuPont Fluoroproducts  
Eaton  
Ecole des Mines de Paris  
Edith Cowan University (Australia)  
Environment Canada  
European Commission  
Fiat Auto  
Four Seasons  
Friends of the Earth  
General Motors  
Goodyear  
Honda  
Honeywell  
Hutchinson FTS

Hyundai  
Indian Institute of Technology Delhi  
Indian Ministry of Environment and  
Forests  
INEOS Fluor  
Institute of Governance and  
Sustainable Development  
International Organization of  
Standardization  
Isuzu  
Japan Automobile Manufacturers  
Association  
Japan Fluorocarbon Manufacturers  
Association  
Japan Industrial Conference for  
Ozone Layer and Climate Protection  
Japan Ministry of Economy, Trade  
and Industry  
Japan Ministry of Environment  
Johnson Controls  
Kia  
Konvekta  
Korea Advanced Institute of Science  
and Technology  
Mafow  
Mitsubishi Motors  
Mobile Air Conditioning Partners  
Europe  
Mobile Air Conditioning Society  
Worldwide  
Modine  
Natural Resources Defense Council  
Nauteonics  
Nissan  
Obrist  
Parker-Hannifin  
PPG Industries  
PSA Peugeot/Citroen  
Red Dot  
Refrigerant Reclaim Australia  
RTI Technologies  
Sander  
Shoeco

Sinochem USA  
Skye International Holdings  
Snap-On Diagnostics  
Society of Automotive Engineers  
Society of Indian Automobile  
Manufacturers  
Solvay Fluorochemicals  
SPX Roblinair  
Subaru  
Subros  
Sun Test  
Suzuki  
TATA Motors  
TEXA, S.p.A.  
Texas Instruments  
The Energy and Resources Institute  
(India)  
TI Automotive  
Toyota  
Tracer Products  
Transpro  
TYC Genera  
Underwriters Laboratories  
United Nations Environment  
Programme DNE  
U.S. Army RDE Command  
U.S. Department of Energy's National  
Renewable Energy Laboratory  
U.S. Environmental Protection Agency  
University of Braunschweig (Germany)  
University of Illinois  
University of Maryland  
UView Ultraviolet Systems  
Valeo  
Vehicle Airconditioning Specialists of  
Australia  
Visteon Corporation  
Volkswagen  
Volvo Car Corporation  
World Resources Institute  
ZIEDEL-Valeo

**Congratulations to the Mobile Air Conditioning Climate Protection Partners for helping us all save money and drive a little cleaner. This global team of corporate, government, and environmental leaders is working together to rapidly improve the efficiency of your vehicle air conditioning systems by at least 30% and reduce refrigerant leakage by at least 50%. Vehicle manufacturers and suppliers are improving existing air conditioning systems and technicians are offering environmentally superior service as the global search for better refrigerants continues. These voluntary actions will ultimately avoid millions of tons of greenhouse gas emissions each year.**

**Visit our website at [www.epa.gov/cppd/mac](http://www.epa.gov/cppd/mac) and help put the environment in the driver's seat.**



# Appreciate The Global Consensus

- An investment of less than \$50 per new vehicle can improve the energy efficiency of AC systems by at least 30% and reduce refrigerant leakage by at least 50%--with payback from fuel savings within two years and savings every year there after.
- Professional system repair using the latest service equipment can further reduce emissions
- New refrigerants can transform markets

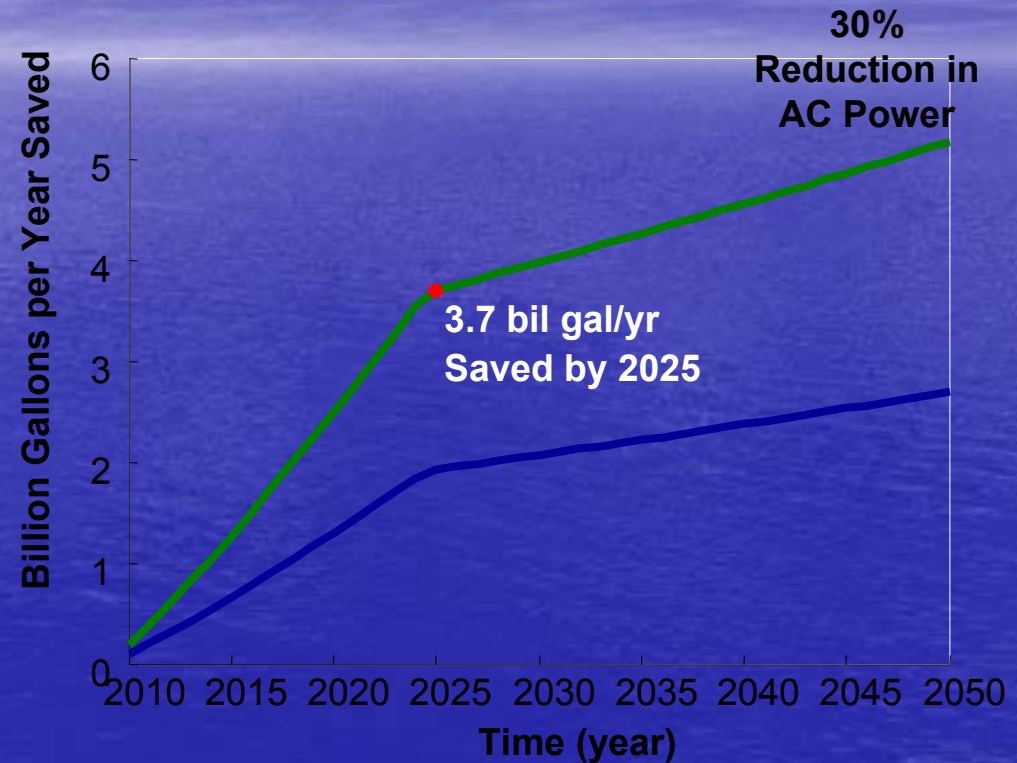
# Performance not Prescription

- Conspicuous Regulatory Neglect
  - Energy use not yet in US EPA fuel economy label or CAFE;  
**ignored in national standards worldwide!**
- The EC ban on HFC Refrigerants does not guarantee reductions in GHGs if fuel use is increased
- CARB performance standards can motivate the choice of best technology and guarantee GHG reductions while saving car owners money and stimulating employment in the vehicle service sector

# U.S. Fuel Savings Taking into Account New Technology Penetration

- Assumptions

- 30% reduction in AC power
- Power reductions begin in 2010
- Fleet grows through time (DOE's Vision model)
  - 234 million in 2010
  - 293 million in 2050
- Fleet turnover in 16 years
- VMT increases over time
  - 13,500 miles in 2010
  - 19,950 miles in 2050



Reduction in Refrigerant GHG Emissions Nearly Doubles the Climate Benefit

# MAC Climate Protection Partnership

- Product Testing
- Labeling of Superior Products
- Incentives for Proper Service
- Rewards for Improving New Car MAC System Energy Efficiency and Refrigerant Containment



***Certified A/C  
Containment***

# First Things First @ CARB

- Take Full Advantage of CARB Membership in MAC Partnership
- Endorse SAE MAC Global Standards
  - Testing, Performance, & Service Standards
- Consider Incentives for New Service Equipment & Enhanced Service Procedures
- Reward Verified Energy Efficiency
- Avoid Snake Oil and...
  - ...Other Claims Too Good To Be True

# More MAC Information

- I-MAC 30/50
  - [www.epa.gov/cppd/mac](http://www.epa.gov/cppd/mac); [www.sae.org/news/releases/mobileac.htm](http://www.sae.org/news/releases/mobileac.htm)
- SAE Alternate Refrigerant Symposium: 26-28 June 2006
  - [www.sae.org/events/aars/](http://www.sae.org/events/aars/); [www.sae.org/ac](http://www.sae.org/ac)
- VDA Winter Meetings
  - [www.vda-wintermeeting.de](http://www.vda-wintermeeting.de)
- MAC Summit Proceedings
  - 2003: [www.europa.eu.int/comm/environment/air/mac2003/index.htm](http://www.europa.eu.int/comm/environment/air/mac2003/index.htm)
  - 2004: [www.epa.gov/cppd/2004macsummit.pdf](http://www.epa.gov/cppd/2004macsummit.pdf)
  - 2005: [www.arb.ca.gov/research/macs2005/macs2005.htm](http://www.arb.ca.gov/research/macs2005/macs2005.htm)
  - 2006: [www.mac-summit.com/presentations](http://www.mac-summit.com/presentations)
- California Climate Protection and MACS
  - <http://www.arb.ca.gov/cc/ccms/ccms.htm>
  - [http://www.climatechange.ca.gov/climate\\_action\\_team/reports/index.html#supporting](http://www.climatechange.ca.gov/climate_action_team/reports/index.html#supporting)
- U.S. EPA MAC Partnership
  - [www.epa.gov/cppd/mac](http://www.epa.gov/cppd/mac)



# **International Symposium on Near-Term Solutions for Climate Change Mitigation in California**

**Ward Atkinson**  
**March 5-7, 2007**



# **Search For The Mobile A/C Refrigerant That Is The Best For The Environment**

## **♦ Must consider:**

- Direct emissions from refrigerant**
  - Potential release to atmosphere over vehicle lifetime**
- Indirect emissions**
  - System total weight [carried on vehicle all year]**
  - System operating efficiency [fuel use] in the warm climate in California**
- Risks to Consumer and technician safety**
- Proven Long term system reliability**
- Costs vs the Benefits**
  - Initial cost of the vehicle**
  - Costs for Service over lifetime**



# Search For The Mobile A/C Refrigerant That Is The Best For The Environment

## ◆ Known Facts:

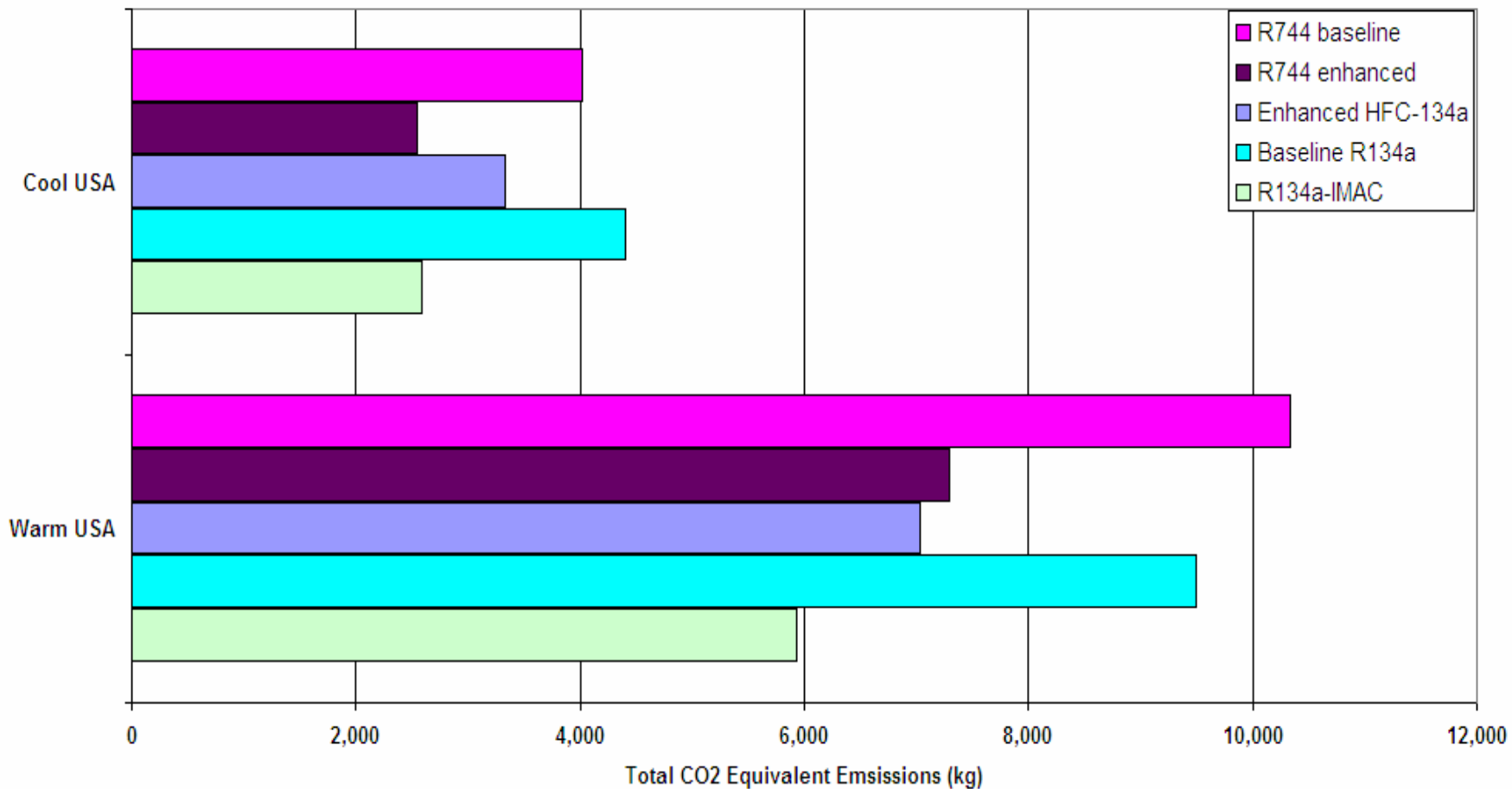
- Current industry targets for new refrigerants is to provide:
  - Comparable system cooling performance to HFC-134a systems
  - Reduced refrigerant requirements over the system's lifetime [**Reduce initial charge and leakage**]
  - Reduced energy consumption [**Improved fuel use**]

## ◆ Compare all A/C systems/refrigerants for total Environmental impact using LCCP standards [Life Cycle Climate] Performance]



# Life cycle analysis

Comparison of Total CO2 Equivalent for Various Refrigerant Alternatives





# Search For The Mobile A/C Refrigerant That Is The Best For The Environment

## ♦ SAE I-MAC Achieved Success in Meeting HFC-134a Goals

- Reduced System Refrigerant Emissions by **50%**
- Improved System Energy Efficiency by **30%**
- Reduced in Vehicle Solar & High Ambient Temperature Heat Loads by **30%**
- Reduced Refrigerant Losses During Service by **50%**



## ♦ SAE J2727

- Developed a Standard to Estimate HFC-134a Annual Mobile Air Conditioning System Refrigerant Emissions



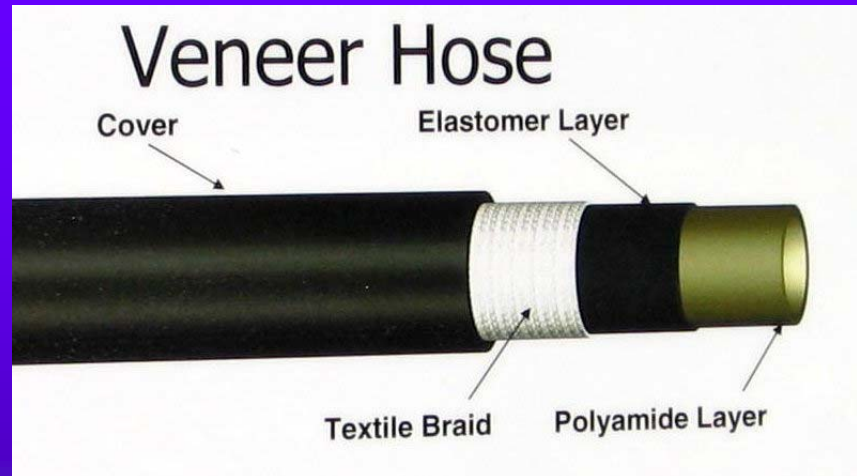
# System Leakage



- ◆ **Compressor Technology**
  - Shaft Seal
  - Housing seals
- ◆ **Hose Technology**
- ◆ **Fitting Connection Technology**

# 3 Types of Hose Construction

## ◆ Ultra-low Perm Barrier or Veneer Hose



**Lowest  
Leakage**

## ◆ Standard Barrier or Veneer Hose

## ◆ All Rubber Hose



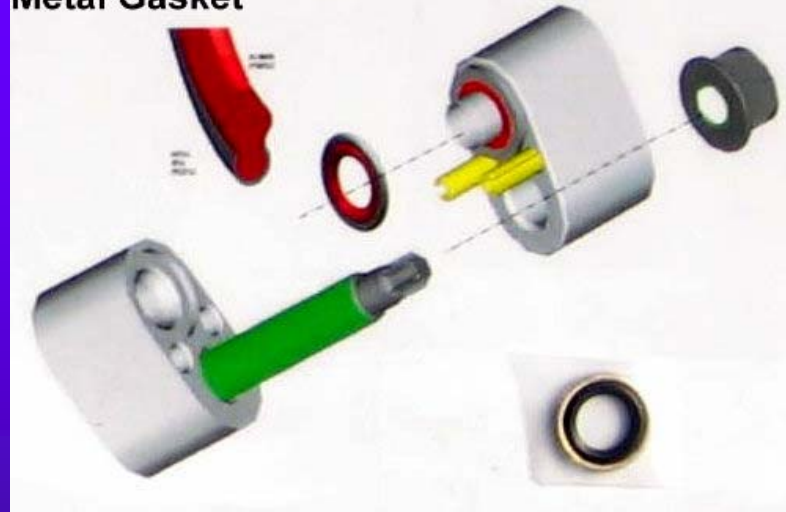


# 6 Types of Rigid Pipe Connections

**Lowest  
Leakage**

- ◆ **Metal Gasket**
- ◆ **Seal Washer with O-ring**
- ◆ **Seal Washer**
- ◆ **Multiple O-ring**
- ◆ **Single Captured O-ring**
- ◆ **Single O-ring**

**Metal Gasket**






# I-MAC Efficiency



**Achieved the 30% goal by:**

- ♦ **Improved heat exchanger technology**
  - Condenser
  - Evaporator
- ♦ **Improved compressor technology**
- ♦ **Improved refrigerant control technology**



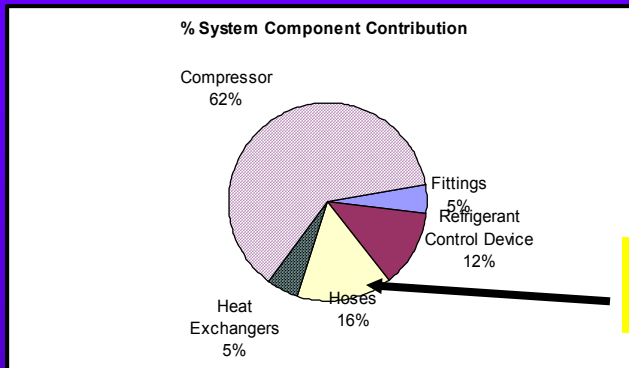
# New HFC-134a Systems For Marketplace

- ◆ **Improved HFC-134a systems**
  - Have less refrigerant leakage
  - Use less refrigerant
  - Are more efficient
- ◆ **Reduced Service refrigerant loss Requires**
  - New service equipment
  - Improved technician training
- ◆ **Added costs can be rewarded using emission credits**



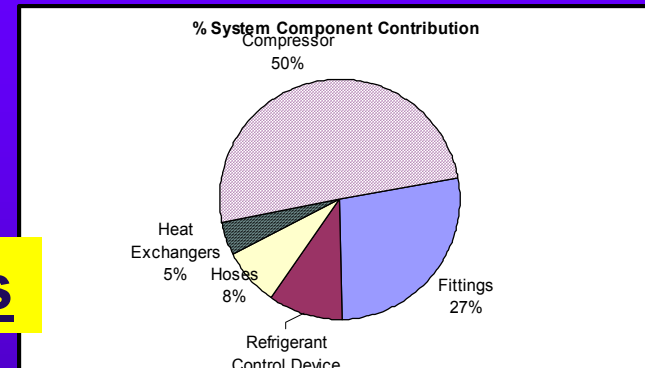
# J2727 HFC-134a Mobile Air Conditioning Estimated System Refrigerant Emission Charts

## ◆ Production System – GM 9.7 grams/yr

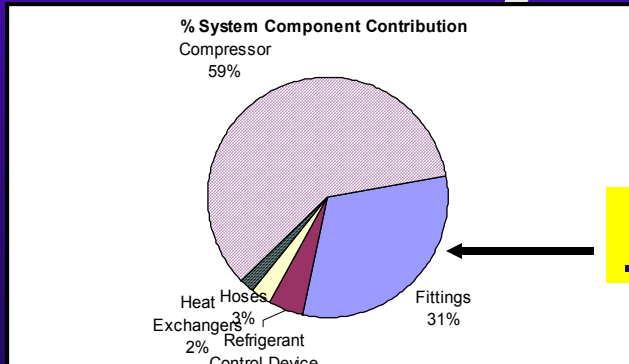


**Hoses**

## ◆ Production System – Ford 10.9 grams/yr

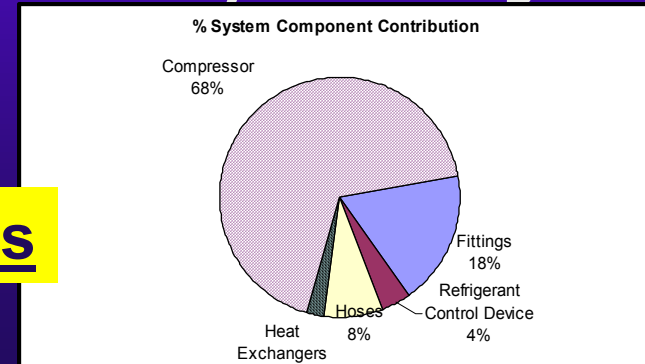


## ◆ Production System – DCX van 25.4 grams/yr



**Fittings**

## ◆ Production System – Toyota 22.3 grams/yr





# New Refrigerants

## ♦ European phase-out of HFC-134a in 2011/2017

### – Alternatives:

- R744 Carbon Dioxide Systems

- Higher Cost
- Less efficient in Warm Climates
- May not be a global refrigerant

- R152a

- Need mitigation due to flammability
- Secondary loop may be an option

- New alternative refrigerants are being evaluated by:

- SAE - CRP-150
- VDA Vehicle test program
- JAMA Program

### – Rest of World may still use HFC-134a

### – Industry Wants a Single Low GWP Global Refrigerant



# New Systems For Marketplace R-744 Carbon Dioxide

- ◆ **R744 Systems Carbon dioxide**
  - Initial use in Europe [Limited to other markets?]
  - If sold in USA meet SNAP requirements
- ◆ **Requires**
  - New service equipment
  - Under current federal regulations cannot be vented at service
  - High pressure system
    - Requires “Certified Technicians”
- ◆ **Production systems may not be as efficient as prototype systems**  
[Less efficient than optimized development systems]
- ◆ **Long term reliability not fully proven**



# **New Systems For Marketplace**

## **HFC-152a**

- ◆ **HFC-152a ( Secondary loop)**
  - **Improved performance over HFC-134a -- Including Idle Stop**
  - **Single component chemical**
  - **Must be recovered at service**
  - **Requires**
    - **New service equipment**
    - **Improved technician training due to flammability**



# Search For A New Global Refrigerant

## ◆ Needs to be

- Energy efficient
- Comparable Performance to HFC-134a
- Safe and not harmful to the environment or the consumer
- Cost effective
- New service equipment



# New Refrigerants

- ◆ Current Industry activity --- Low GWP Refrigerants

- ◆ New candidates  
-- Low GWP Blend Refrigerants

Industry will select from candidates:

- Arkema
- Dupont DP1
- Honeywell Fluid H
- Ineous Fluor Auto AC-1
- Sinochem
- Solvay

- ◆ New Refrigerant Are Blends

- azeotropes/zeotropes
- Some blend compositions remain the same (won't separate)
- Some blend compositions can separate, change over vehicle life

- ◆ Not a single chemical like HFC-134a/HFC-152a



# New Blend Refrigerants

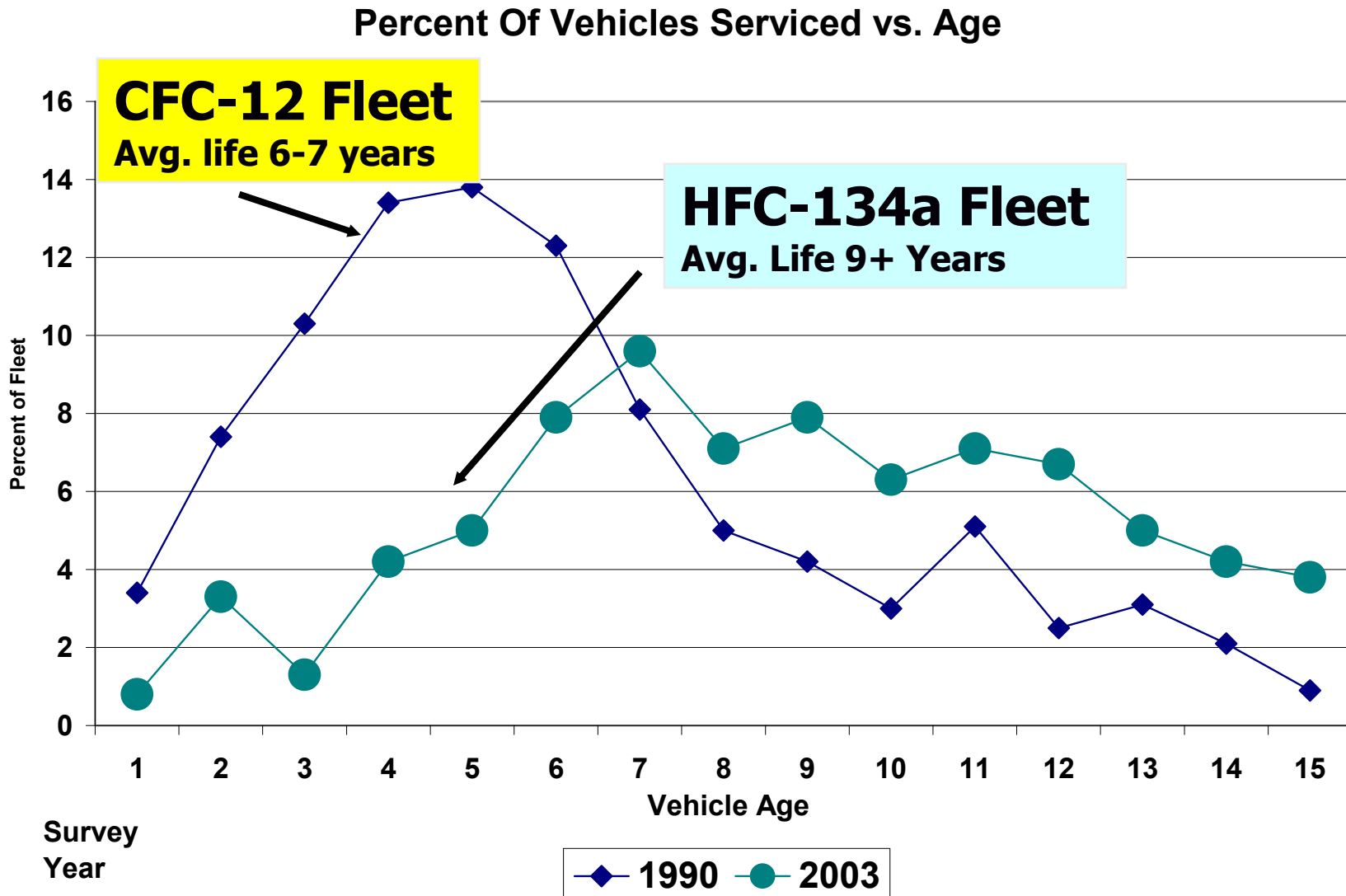
- ◆ In general have less performance than HFC-134a
  - Require new system component development
    - Potential For Improvement
      - Heat exchangers
      - Compressors
- ◆ Require complete analysis for
  - Health and safety
  - Environmental impact
  - Meeting governmental requirements
    - SNAP ---- TSCA
- ◆ Must meet system material compatibility
  - Hoses --- seals
- ◆ Have temperature/pressure relationship similar to HFC-134a



# New Blend Refrigerants

- ◆ **Recovery**
  - None can be Vented at service or end of vehicle life
- ◆ **On site Recycling Currently unknown**
  - Might require re-formulation before re-use
  - Might require recovery and return to supplier
- ◆ **Requires unique tools and service equipment**

# Independent Service Facility A/C System Service Profiles





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# **Immediate Impact on Greenhouse Gas**

## **■ Incentives**

- ◆ Superior leak detection & recovery/charging equipment**

## **■ Regulations**

- ◆ Require return of refrigerant containers for refrigerant heel and container recovery**

# **Society of Automotive Engineers Cooperative Research Program**

**Reduce Service  
Emissions by 50%**



**Identify, quantify and  
propose remedies for  
refrigerant losses at  
service, vehicle end of life**

**Evaluate and recommend  
improvements for service  
tools, equipment (new or  
revised standards) and  
service procedures**

**Quantify and address  
losses from one-way  
refrigerant containers**

**Produce educational  
programs and conduct  
outreach to reduce  
refrigerant emissions**

# I-MAC Service Team



- Refrigerant measurement
  - ◆ Recovery/charging
- Leak detection
- Field coupled hoses
- Container emissions (heel)
- Communication to vehicle salvage industry

# **Service Problems Identified: Leaks & Refrigerant Recovery**

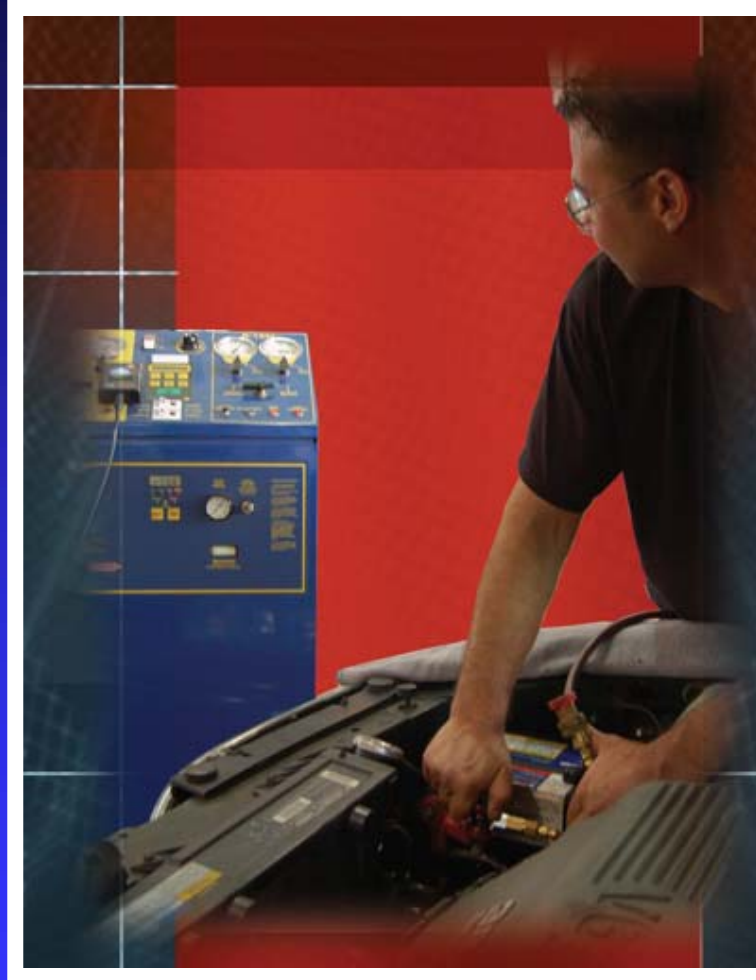


- **20 to 30% of refrigerant is not recovered at service & EOL**
- **Significant GHG Emissions**
- **Overcharged systems increasing fuel use, damaging components & possible pressure relief venting**

# Solution: New Refrigerant Recovery Equipment



**Old J2210**  
**70%**  
**Refrigerant**  
**recovered**  
**at service**  
**and EOL**



**New J2788**  
**95%**  
**Refrigerant**  
**recovered**

***Drivers:***

- ***SAE***
- ***EPA & CARB Regulations***
- ***MACS and industry***

# **Solution:**

## **Superior Leak Detectors**



### **■ J1627**

- ◆ **Required only 1 range scale**
- ◆ **Identified 0.5 ounce/year with probe 1/4 inch from leak**

### **■ J2791**

- ◆ **New test procedure for certification**
- ◆ **Requires at least 3 selectable ranges**
- ◆ **Identifies 0.15 ounce/year with probe 3/8 inch from leak**

# Field Coupled Hose Assemblies



- As much as 50% of replacement A/C hoses are field coupled
- As much as 15% of field coupled hoses are defective
- Extreme inconsistency in sizing and materials selection of field coupling hose assemblies
- Wide variation in crimping styles, techniques and dimensional integrity

# **Solution: Shops Compliance with SAE J2064**



- **Factory certified assemblies or certified field hose coupling with proper equipment**
- **Standardized components and proper component matching**
- **Audited shop testing standards**

# HFC-134a Vehicle System and Service Technician Certification

- Programs identifying:
  - ◆ New HFC-134a systems
    - ◆ Reduced leaks
    - ◆ Improved efficiency
- I-MAC Facility and Technician Certification Programs



***Certified A/C  
Containment***

# Vehicle End of Life



- Continuing cooperation with the Automotive Recyclers Association (ARA) & the Institute of Scrap Recycling Industries (ISRI)

# Proposed Blend Refrigerants

- Proposed blend refrigerants will have a major impact on service
- Each new refrigerant would require unique training, tools, and service equipment

# Can CARB Find the Way?

- **Require reduced leakage, energy-efficient systems in new cars**
- **Encourage certified, professional training & the use of improved tools and equipment**
- **Require return of refrigerant containers for refrigerant heel recovery and container salvage (30 Lb. containers)**